

CLAIMS

1. A process for producing a soluble starch hydrolysate, the process comprising subjecting an aqueous granular starch slurry at a temperature below the initial gelatinization temperature of said granular starch to the action of a first enzyme and a second enzyme, which first enzyme;
 - (a) is a member of the Glycoside Hydrolase Family13;
 - (b) has alpha-1.4-glucosidic hydrolysis activity, and;
 - (c) comprises a functional Carbohydrate-Binding Module (CBM) belonging to CBM Family 20, which CBM has an amino acid sequence having at least 60% homology to an amino acid sequence selected from the group consisting of SEQ ID NO:1, SEQ ID NO:2, and SEQ ID NO:3;and which second enzyme is selected from the list comprising a fungal alpha-amylase (EC 3.2.1.1), a beta-amylase (E.C. 3.2.1.2), and a glucoamylase (E.C.3.2.1.3).
2. The process of the preceding claim, wherein the alpha-amylase comprises a functional Carbohydrate-Binding Module having at least 55%, at least 60%, at least 65%, at least 70%, at least 75%, least 80%, at least 85%, at least 90%, least 95%, at least 98%, such as at least 99% homology to an amino acid sequence selected from the group consisting of SEQ ID NO:1, SEQ ID NO:2, and SEQ ID NO:3
3. The process of any of the preceding claims, wherein the alpha-amylase comprises an amino acid sequence having at least 75%, least 80%, at least 85%, at least 90%, least 95%, at least 98%, such as at least 99% homology to an amino acid sequence selected from the group consisting of SEQ ID NO:4, SEQ ID NO:5, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:11, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:14, SEQ ID NO:15, SEQ ID NO:16, SEQ ID NO:17, and SEQ ID NO:18 .
4. The process of any of the preceding claims, wherein the alpha-amylase comprises an amino acid sequence having at least 75%, least 80%, at least 85%, at least 90%, least 95%, at least 98%, such as at least 99% homology to an amino acid sequence selected from the group consisting of SEQ ID NO:19, SEQ ID NO:20, SEQ ID NO:21 and SEQ ID NO:22.
5. The process of any of the preceding claims, wherein the starch slurry has 20-55% dry solids granular starch, preferably 25-40% dry solids granular starch, more preferably 30-35% dry solids, especially around 33% dry solids granular starch.

6. The process of any of the preceding claims, wherein at least 85%, 86%, 87%, 88%, 89% least 90%, 91%, 92%, 93% 94%, 95%, 96%, 97%, 98% or at least 99% of the dry solids of the granular starch is converted into a soluble starch hydrolysate.
7. The process of any of the preceding claims, comprising subjecting the granular starch slurry to the action of an isoamylase and/or a pullulanase.
8. The process of any of the preceding claims, wherein the temperature is at least 58°C, 59°C, or more preferably at least 60°C.
9. The process of any of the preceding claims, wherein the pH is in the range of 3.0 to 7.0, preferably from 3.5 to 6.0, or more preferably from 4.0-5.0.
10. The process of any of the preceding claims, wherein the soluble starch hydrolysate has a DX of at least 94.5%, 95.0%, 95.5%, 96.0%, 96.5%, 97.0%, 97.5%, 98.0%, 98.5, 99.0% or at least 99.5%.
11. The process of any of the preceding claims, wherein the granular starch is obtained from tubers, roots, stems, or whole grain.
12. The process of any of the preceding claims, wherein the granular starch is obtained from cereals.
13. The process of any of the preceding claims, wherein the granular starch is obtained from corn, cobs, wheat, barley, rye, milo, sago, cassava, tapioca, sorghum, rice or potatoes.
14. The process of any of the preceding claims, wherein the granular starch is obtained from dry milling of whole grain or from wet milling of whole grain or from milled corn grits.
15. The process of any of the preceding claims, wherein the process is conducted in an ultrafiltration system and where the retentate is held under recirculation in presence of enzymes, raw starch and water and where the permeate is the soluble starch hydrolysate.
16. The process of any of the preceding claims, wherein the process is conducted in a continuous membrane reactor with ultrafiltration membranes and where the retentate is held under recirculation in presence of enzymes, raw starch and water and where the permeate is the soluble starch hydrolysate.
17. The process of any of the preceding claims, wherein the process is conducted in a continuous membrane reactor with microfiltration membranes and where the retentate is held under recirculation in presence of enzymes, raw starch and water and where the permeate is the soluble starch hydrolysate.

18. A process for production of high fructose starch-based syrup (HFSS), wherein a soluble starch hydrolysate of the process of any of the preceding claims is subjected to conversion into high fructose starch-based syrup (HFSS), such as high fructose corn syrup (HFCS).
19. A process for production of a fermentation product, wherein a soluble starch hydrolysate of the process of any of claims 1-18 is subjected to fermentation into a fermentation product, such as citric acid, monosodium glutamate, gluconic acid, sodium gluconate, calcium gluconate, potassium gluconate, glucono delta lactone, sodium erythorbate, itaconic acid, lactic acid, gluconic acid; ketones; amino acids, glutamic acid (sodium monoglutamate), penicillin, tetracyclin; enzymes; vitamins, such as riboflavin, B12, beta-carotene or hormones.
20. A process for production of fuel or potable ethanol, wherein a soluble starch hydrolysate of the process of any of claims 1-18 is subjected to fermentation into ethanol.
21. The process of the preceding claim, wherein the fermentation step is carried out simultaneously or separately/sequential to the hydrolysis of the granular starch.
22. The process of any of the claims 1-14, wherein the process is conducted in an ultrafiltration system where the retentate is held under recirculation in presence of enzymes, raw starch, yeast, yeast nutrients and water and where the permeate is an ethanol containing liquid.
23. The process of any of the claims 1-14, wherein the process is conducted in a continuous membrane reactor with ultrafiltration membranes and where the retentate is held under recirculation in presence of enzymes, raw starch, yeast, yeast nutrients and water and where the permeate is an ethanol containing liquid.
24. The process of any of the claims 1-23, wherein the starch slurry is being contacted with a polypeptide comprising a CBM, but no catalytic module, i.e. a loose CBM.
25. A use of an enzyme having alpha-amylase activity in a process for hydrolysis of starch, said enzyme comprising a functional CBM having an amino acid sequence having at least 60% homology to an amino acid sequence selected from the group consisting of SEQ ID NO:1, SEQ ID NO:2, and SEQ ID NO:3.
26. A use of an enzyme having alpha-amylase activity in a process for hydrolysis of granular starch, said enzyme comprising an amino acid sequence having at least 75%, least 80%, at least 85%, at least 90%, least 95%, at least 98%, such as at least 99% homology to an amino acid sequence selected from the group consisting of SEQ ID NO:4, SEQ ID NO:5, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ

ID NO:11, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:14, SEQ ID NO:15, SEQ ID NO:16, SEQ ID NO:17, and SEQ ID NO:18.

27. A use of an enzyme having alpha-amylase activity and a functional CBM in a process for hydrolysis of granular starch, said enzyme comprising an amino acid sequence having at least 75%, least 80%, at least 85%, at least 90%, least 95%, at least 98%, such as at least 99% homology to an amino acid sequence selected from the group consisting of SEQ ID NO:19, SEQ ID NO:20, SEQ ID NO:21 and SEQ ID NO:22.